Applicant's Informal Comments on ISA Opinion

(1) Points of ISA opinion

The inventions defined by claims 1, 4, and 5 do not involve an inventive step from the following document 1.

The invention defined by claim 2 does not involve an inventive step from the following documents 1 and 2.

The invention defined by claim 3 does not involve an inventive step from the following documents 1 and 3.

Document 1: JP 6-14929 A

Document 2: JP 10-118063 A

Document 3: JP 2001-340338 A

(2) The present invention achieves a particular effect that a high-quality ultrasonic image that is well defined in detail with reduced stripes in a direction in which acoustic lines are arranged can be displayed by optimizing filtering processing with respect to signals between a plurality of reception beams obtained from a single transmission beam.

(3) The document 1 discloses an acoustic imaging system having a plurality of acoustic transducer elements, means connected to the plurality of transducer elements for generating a transmission acoustic beam for interrogating an object, means connected to the plurality of transducer elements for receiving signals from a reception acoustic beam, and means responsive to received acoustic signals for generating image signals in a first format, the system including converter means responsive to the image signals for generating image display signals in a second format that is suitable for visual display, means connected to the converter means for detecting and controlling the

image display signals, and means responsive to the detected and controlled image display signals for generating a visual display of the object.

An operation and an effect of the above system are considered schematically as follows.

a) Scan conversion or data interpolation is performed on the signal generated by the transducers so as to improve resolution before the signal is processed by detecting and limiting it. (see paragraph 0012).

b) A nonlinear interpolation scheme is used during the scan conversion process so as to reduce the artificiality (see paragraph 0013).

c) Acoustic lines spaced on a grid uniform in the reciprocal of the cosine of the scanning angle increase the frame rate without decreasing image resolution (see paragraph 0014).

d) The angular separation between acoustic lines is increased to reduce the number of lines shot, and the existing data are interpolated, whereby the frame rate is increased (0015).

Therefore, the invention of the present application is different from that described in the document 1 in the following ways.

1) The present invention is directed to a filter in the first format as in the document 1. On the other hand, the invention described in the document 1 is directed to the conversion from the first format into a second format, i.e., the conversion from acoustic signal scan into display monitor scan.

2) The ultrasonic diagnosis apparatus according to the present invention has a parallel reception function of forming a plurality of reception beams from a single transmission beam. However, the document 1 does not describe the parallel reception function. More specifically, in the present invention, a plurality of reception beams are formed at a time by a single transmission of a beam. On the other hand, in the document 1, a single transmission of a beam allows a single reception beam to be formed, and signals for interpolating between reception beams are generated by

combining reception beams obtained by two transmissions of beams.

3) The present invention improves image quality that is degraded due to the fact that a signal difference between a plurality of reception beams obtained from a single transmission beam with a parallel reception function is smaller than a signal difference between reception beams obtained from different transmission beams. On the other hand, the system in the document 1 improves image quality that is degraded by the conversion from the first format into the second format, i.e., the conversion from the acoustic signal scan into the display monitor scan.

(3) The document 2 describes an ultrasonic diagnosis apparatus including a transmission circuit for carrying out electronic scanning of a plurality of ultrasonic oscillators provided in an ultrasonic probe so as to form a transmission beam, two reception beam forming portions for forming two reception beams from a single transmission beam, a wave transmission/reception portion for shifting a transmission/reception beam pattern with respect to each scanning frame by a width half the transmission beam pitch, a frame memory and an adding circuit for synthesizing the reception beams between scanning frames, and a display unit for displaying a synthesized beam converted into image information.

The apparatus in the document 2 achieves an effect of reducing generation of striped patterns in a diagnostic image due to nonuniform correlations between the beams (see Abstract). The present invention is different from the invention in the document 2 in the following ways.

The apparatus in the document 2 is directed to processing performed "…in units of predetermined frames …" as recited in the claims. Specific differences between the present invention and the invention in the document 2 are as follows.

1) The present invention is directed to a spatial filter for acoustic image data on a single frame in ultrasonic scanning frames formed of a

plurality of reception beams. On the other hand, the invention in the document 2 is directed to an interpolated beam or a synthesized beam generated between ultrasonic scanning frames.

2) The present invention is directed to a spatial filter for acoustic image data between different reception beams on a single frame. On the other hand, the invention in the document 2 is directed to an interpolated beam or a synthesized beam with respect to acoustic image data on a corresponding reception beam generated between ultrasonic scanning frames.

3) The present invention suppresses generation of boundaries or stripes between reception beams that are noticeably visible in two-dimensional Doppler because a large amount of time elapses between different transmission beams since transmission and reception is repeated about ten times on the same acoustic line so as to detect a temporal variation. On the other hand, according to the invention in the document 2, the transmission circuit shifts the transmission beam pattern in units of predetermined scanning frames, so that a combination of strongly correlated reception beams is changed with respect to each scanning frame. As a result, nonuniform correlations between reception beams are modified, thereby reducing unevenness of diagnostic images (see paragraphs 0017, 0021, and 0024).

4) Namely, the present invention can also be used effectively to provide a diagnostic image of an active-moving region such as a cardiac region. However, the invention in the document 2 can only be used effectively to provide a diagnostic image of a slow-moving region, since this invention is based on the assumption that the formed synthesized beam has the same correlations with both adjacent beams between scanning frames.

(4) The document 3 describes that a control portion is provided for changing a filter coefficient in a direction from the vicinity of a surface of an oscillator toward a distal point in acoustic data in spatial filter processing and that the

acoustic data before coordinate transformation are subjected to spatial filter processing and the filter processing coefficient is changed in accordance with a distance on the acoustic line data. Consequently, distal point noise is reduced, while resolution at a near point is prevented from decreasing, resulting in an ultrasonic image with increased quality (see Abstract). Therefore, the present invention is different from the invention in the document 3 in the following way.

1) The ultrasonic diagnosis apparatus according to the present invention has a parallel reception function of forming a plurality of reception beams from a single transmission beam. However, the document 3 does not describe the parallel reception function. More specifically, the present invention improves degradation in image quality such as generation of stripes or noticeably visible boundaries due to the fact that a signal difference between a plurality of reception beams obtained from a single transmission beam with a parallel reception function is smaller than a signal difference between reception beams obtained from different transmission beams. Further, the present invention is characterized in that filter coefficients are adjusted and controlled in accordance with a receiving depth, an angle of the reception beam, or a focal position of a transmission beam. On the other hand, the invention in the document 3 improves image quality by avoiding a decrease in resolution at a near point due to a reduction in distal point noise in the case where the spatial filter processing is performed equally regardless of a depth (see paragraphs 0015, 0032, 0046, and 0051).

(5) As described above, the present invention achieves the following particular effect that cannot be obtained by any combinations of the above references.

According to the present invention, filtering processing with respect to signals between a plurality of reception beams obtained from a single transmission beam is optimized, whereby it becomes possible to display a

high-quality ultrasonic image that is well defined in detail with reduced stripes in a direction in which acoustic lines are arranged.